SCIENCE

VOL. LVI NOVEMBER 17, 1922 NO. 1455

CONTENTS

SCIENCE: A Weekly Journal devoted to the Advancement of Science, publishing the official notices and proceedings of the American Association for the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

11 Liberty St., Utica, N. Y. Garrison, N. Y.

New York City: Grand Central Terminal

Annual Subscription, $6.00 Single Copies, 15 Cts.

Entered as second-class matter January 21, 1922, at the Post Office at Utica, N. Y., Under the Act of March 3, 1879.

CHANGES OF LATITUDE

IN this era of changes of every description, the question of changes of position of our astronomical observing stations on the surface of the earth has recently become a live issue. The question is still an open one, and its ultimate decision may rest upon a comparison of the precision of the results of observation with the size of the changes predicted or adopted by geologists.

California has undergone some severe earthquake shocks, of which we commonly talk but little and endeavor to think not at all. Of the modern disturbances, that of 1906 was clearly due to a slip at the surface of the earth along a geological fault line. At the location of this fault the relative slip of the two opposite sides was as much as twenty feet in some places. There is no such evidence available for any other earthquake, but it may be assumed that other shocks in this coastal region were of similar nature.

In Japan, where some five hundred earthquakes of sensible character have been recorded in twenty years, the shocks are presumably not due to slips at the surface along geological faults.

The only extensive results of astronomical observations in this region are those at the Lick Observatory, where meridian circle work has been prosecuted for nearly thirty years, and at Ukiah, about a hundred and fifty miles northwest of us, where zenith telescope work has been carried on continuously for twenty years. There have been isolated zenith telescope determinations of latitude, but they would contribute little of importance to the discussion of progressive or abrupt changes, owing to the uncertain errors of the star declinations adopted.

For instance, the latitude of our instrument, as furnished by the U. S. Coast and Geodetic Survey in the early days, was 37° 20′ 24.48″.

This value is more than a second of arc smaller than the one derived from our meridian circle observations, beginning in 1893. Errors of the old observations, including those of the star declinations, the lack of corrections for latitude variations, and the errors of the geodetic triangulation probably account fully for this difference. It appears not to have been quoted as an illustration of geological change. Possibly it is so large as to be out of bounds. The range of movements under discussion at present is usually from one to five feet. There was a notable earthquake in 1868, possibly due to a fault slip. It would, however, be difficult to assign the proper proportions of a difference of a second of arc to the errors of observation and to the slipping, if the 1868 shock is to be made responsible for its part.

The meridian circle results include the epochs of the earthquakes of 1895, 1903, 1906 and 1911. The first one of these was less intense than the others. The observations at Ukiah include the epochs of the last three.

On request for our data, the results given in the column Observed φ_0 below were originally compiled in quarterly values, the observations of each month having been combined into means of the values of two or three months. The table gives the number of successive quarterly values that make up the respective annual values of φ_0. In the annual φ_0 some of the periodic errors due to declination have been eliminated. There are some gaps in the sequence of observations, one from 1908 to 1912 due to my absence at San Luis, Argentina, for the work of the Carnegie Southern Observatory.

The system of standard stars in use varied from time to time, for special reasons of program and international projects of observation, and in the column of Corrected φ_0 the systematic corrections derived from the various authorities have been applied as far as is possible. The reduction has thus been made to the system of auwers, for which a correction of approximately $+0.1''$ may still be required, to give us the true astronomical latitude of our instrument. The average residual of the last column is two thirds the size of that of the column preceding.

There are more stars in the catalog of Newcomb, and rigorous systematic corrections can not be derived for the extra stars. The latitude results during the use of his system, in the years 1901 to 1904, are nearly $0.1''$ higher than those of the remaining years. Some additional results are included in the last column.

Treated as a consecutive series, from 1893 to 1921, there is no sensible continuous progressive change of latitude from the mean, $37° \; 20' \; 25.6''$. To illustrate the effect of abrupt changes at the epochs of earthquakes, the yearly results have been combined in groups, corresponding to each of three shocks. The small differences thus exhibited are such as would be expected, from the accidental errors of the yearly means. The influence of the high point in the series, where the declinations of Newcomb were employed, is felt in the combinations. There will be an apparent progressive rate up to that point and a drop thereafter which are probably fictitious. The mean values of φ_0 preceding 1901 and following 1904 have excluded the effect of the systematic difference due to Newcomb.

The errors in determining the declinations of stars are smaller than those involved in latitudes, since some of the important systematic errors can be eliminated. The probable error of the annual φ_0 is evidently too large to permit the detection of real changes that do not exceed $0.05''$. Differences of $0.1''$ would be anticipated for half the comparisons between separate yearly means, according to the law of distribution of errors, and three differences as large as $0.2''$ might occur in a run of 18 differences.

The following computed latitudes for Ukiah differ from the true values by a systematic constant. The effect of the fourteen month term is eliminated in the mean of any fourteen consecutive monthly values. The effect of the annual term is eliminated in twelve. By taking means of fourteen consecutive values, beginning each series with the first month of a year, each mean below is subject to a correction for two extra months of the annual term—a small constant for all of them. No corrections need be computed for either term in this

method, and no assumption need be made as to the invariability of the coefficients of either term. The means are thus well adapted to show progressive or abrupt changes in latitude. The annual rate is quite precisely the mean rate for all the international zenith telescope stations, +0.005″ per year. A systematic correction to the proper motions, as originally computed for their star list, would account for this common rate. Its application gives the last column of the Ukiah results, and its effect is to diminish the average residual from 0.034″ to 0.027″.

LICK OBSERVATORY LATITUDE

MERIDIAN CIRCLE

Epoch	No.	Obs. φ_0	Corr. φ_0
1894.2	4	25.52″	25.52″
5.2	4	53	53
6.1	3	70	70
7.0	4	46	58
8.0	4	72	57
9.2	4	76	59
1901.1	4	83	74
2.3	4	81	74
3.2	4	74	67
4.1	3	50	47
6.0	4	47	47
7.3	3	....	61
8.0	2	37	42
12.6	4	64	64
13.3	2	50	50
14.5	4	61	61
16.7	4	....	56
17.6	5	50	55
21.6	3	....	77
Mean		25.60	25.59
Av. residual		±0.12	±0.08
Preceding 1903			25.62
Following 1903			.56
Preceding 1906			25.61
Following 1906			.58
Preceding 1911			25.59
Following 1911			.60
Newcomb, 1901 to 1904			25.65
Preceding 1901			25.58
Following 1904			.57

UKIAH, ZENITH TELESCOPE

FOURTEEN MONTH MEANS

Epoch	(φ_0)	Rate
1902.6	12.08″	12.12″
3.6	12	16
4.6	12	15
5.6	11	14
6.6	11	13
7.6	11	13
8.6	09	10
9.6	15	16
10.6	16	16
11.6	16	16
12.6	14	13
13.6	13	12
14.6	19	17
15.6	24	22
16.6	21	18
19.6	16	12
20.6	10	05
Mean	25.14	12.14
Av. residual	± 0.034	±0.027
Preceding 1906	14.107	14.142
Following 1906	153	142
Preceding 1911	14.117	14.139
Following 1911	167	141

Rate +0.005″ per year.

The probable error of a yearly zenith telescope latitude is evidently about one third that of the meridian circle results. There are approximately 3,000 observations per year in the former, and 800 in the latter. Both classes of observations are subject to systematic errors that produce larger errors in the mean results than would be due to accidental errors of observation only. The purely accidental error of a single meridian circle observation of a star is closely ±0.2″. With graduation error, and the error of nadir reading included, the probable error of a single latitude observation is closely ± 0.3″. The single zenith telescope observations have probable errors of about half this size. The same list of stars was used throughout at Ukiah, while the list varies for nearly every year at Lick.

There is no evidence at Ukiah of an abrupt change in latitude at the epochs of the 1906 and 1911 earthquakes. An average difference of 0.04″ would be expected between any two yearly results. Ukiah lies 26 miles east of the 1906 fault line, and Mount Hamilton is 22 miles east. These distances have generally been concluded to be too large to show any indication of movement at the stations. The positions of the faults responsible for the 1903 and 1911 shocks do not appear to be on record.

Without implying anything in the nature of an apology for the quality of modern astronomical work, we must conclude that it is hardly a criterion for such small changes as are at issue in this case. The principle of natural selection, useful as it may have been in the domain of biology, must be used sparingly, if at all, in astronomical results. This does not preclude taking note of systematic errors, for the existence of which there is evidence all too ample for our purpose of as high precision as we can reach.

The differential results of the triangulation of the U. S. Coast and Geodetic Survey, covering many points in the neighborhood of the 1906 fault, appear to furnish a more precise criterion. The closing error of each triangle represents the errors of observation. No one questions the usefulness of this device, nor its validity, for the purpose of deriving the best individual results available. We commonly follow the same process in fundamental astronomical work, when we derive systematic corrections to right ascensions, by closing a cycle of a year of continuous differential results. An apt illustration, also, is the measure of graduation errors. The sum of the errors of the divisions of one circle must be exactly zero, when we arrive at the starting point of the measures, having gone round the circle. The average closing error for primary triangulation work appears to be about two seconds. Its proportional part must be assigned, as accidental error, to any absolute determination of a point, by the triangulation.

The probable error of an observed direction, for primary work, appears to be less than one second of arc. For secondary triangulation it is between one and two seconds, and for tertiary work it may be as much as five seconds.

One should guard against the assumption that the probable errors are small for any special triangle, when its closing error is small. This error is made up of several constituent parts, and they may balance in the sum of their effects; just as we have zeros in any list of residual errors and also have some residuals as large as three or four times the probable error of the individual results.

The following data have been taken from the reports for 1907 and 1910.

The test of changes in position at several miles from the fault line may be assumed to rest on the triangulation net from the base line between *Mocho* and *Mt. Diablo*. This is not a measured base, but has been connected up with the *Pulgas* base, south of San Francisco. The base line is about 36 miles long, and it lies 33 miles east of the fault, with which it is approximately parallel.

The changes of the tabulated latitudes of 41 stations, between measures before and after 1906, have been summarized below. Each group includes points on both sides of the fault at nearly the same distances. On the east side the average change is 0.02″ south, and on the west the average is 0.05″ north. The average of all changes is 0.04″, and all groups show a plus relative displacement for west minus east. The latitude of the center of the base line is 37.7°.

No.	φ	From Fault	Rel. Dis.
7	37.8°	11 miles	+0.03″
8[1]	37.7°	3 miles	+0.07″
12	38.5°	1 mile	+0.09″
10	38.9°	3 miles	+0.11″
4	37.0°	14 miles	+0.03″

The *Mocho-Diablo* base line, being 33 miles from the fault, one second of arc in the observed direction is represented by nearly a foot lineal measure, (0.01″), at the fault line. At 80 miles, a second of arc is represented by two feet. The average displacements of the groups are from two to eight times the lineal measure of a second of arc, at the respective distances. *Farallon* is the only station west of the fault showing a sensible change (0.027″) at a relatively great distance, 22 miles. The change of 2.7 feet is quite precisely twice the lineal measure of a second of arc, at its distance from the base line.

No change of latitude was found for the station, Mount Hamilton. This point is 12 miles southwest of *Mocho,* and at this distance one foot on the surface is represented by over three seconds of arc, in the observed direction. This result would indicate also that there was no sensible change at the date of the 1903 earthquake, unless the station returned to its original position by an almost equally precipitate movement.

These lineal equivalents are of course only true for arcs measured at right angles to the respective lines of sight. But the relative positions of the base line and points along the fault are in general favorable for the measurement of displacements in latitude, especially for the stations between 37° and 38°. *Farallon* lies almost due west from the center of the line, but was not observed from either end, its position being fixed by directions from stations

[1] One omitted, residual ten times the average.

close to the Coast, in the succeeding net of triangles.

The criterion then is whether the directions of the points in the neighborhood of the fault have been measured within accumulated errors of observation of the order of a second of arc. Apparently, for all stations which are close to each other, though distributed on both sides of the fault, any errors in the adopted positions of *Mocho* and *Diablo* would be systematic in their effect upon relative displacements, affecting all stations alike.

In the summations of the changes at the various stations in groups, the computed probable error of a mean displacement is ±0.005″, or half a foot. Such precision is apparently five times that of the yearly zenith telescope results.

In the astronomical observations, one foot on the surface is closely equivalent to one one-hundredth of a second in latitude. In geodetic triangulation, one foot on the surface is equivalent to one second of arc, in the direction of a point forty miles distant.

On these grounds we may conclude that the precise differential results of triangulation are better tests for very small changes on the surface than astronomical observations of an absolute character.

R. H. TUCKER

LICK OBSERVATORY,
SEPTEMBER 30, 1922

CONSERVATION AND MODERN LIFE[1]

THIS is an age of high pressure living, of seemingly increasing complexity. Our modern civilization is making such insistent demands upon us that unless we counter by equally insistent measures of self-restraint we must be overwhelmed. Am I drawing too dark a picture or using too strong words? Look into your own experience and see if your success has not been due, in part, at least, to your resistance of certain tendencies and demands, or your failure in some particular to your inability or disinclination to combat some urge, external or internal. It is true, of course, that our lives must be shaped by the culture in which we live, but it is equally true that we must do our share in shaping that culture. Mere following the line of least resistance, passive floating with the tide helps neither our civilization, our fellows nor ourselves.

This is an era of conservation. Its spirit is in the air. We are coming to realize more and more that we must conserve our resources if we are to maintain a high place in the present organization of the community. This statement holds true whether we consider our material resources or our immaterial assets, whether we look to the preservation of our own status or to the maintenance of society. It is with this necessity in mind, then, that I venture to call to your attention a few facts and principles upon which we may base our attitude toward the broader aspects of conservation. And because there is just as urgent need for conserving the elements which shall minister to our inner lives and experiences as there is for guarding those resources of more material nature I shall not confine myself strictly to those ponderable and tangible features which are usually grouped under the conservation movement.

Now whether we call ourselves conservationists or conservatives is just now of little moment. We shall find much in common in the two terms and the values they subserve. Do not both of them imply the clinging to and the preservation of all that is best in the heritage which has been bequeathed us? And what a rich heritage that has been! To what a wealth of treasure have we become heirs, whether we count our physical resources or those of spiritual natures and use. But with the conservative spirit there must also be mingled a real progressivism. Conservatism easily becomes reactionism, as progressivism is in danger of becoming radicalism if they are not actuated by a keen sense of balance. We find abundant exemplification of these statements in present day politics and in history, in the wastage of natural resources or in their undue withholding from proper use, in extreme tendencies in social life and customs, whether it be a clinging to the habits of the past or a hasty adoption of the fads of the present.

[1] Presidential address read before the Iowa Conservation Association at the Charles City meeting, July 13, 1922.